

bamboo

Vol. 21 No. 1

bulletin



BAMBOO SOCIETY of AUSTRALIA inc.

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Front Cover: Detail of Giant Grass' Zome (p 19).

Opposite page:

Dried culms of *Gigantochloa atrovioacea* var. *watupawan*.

Reader Contributions

We would love to publish your bamboo experiences. If you would be interested in sharing your information on bamboo growing, managing, building or cooking, send text and attached photos to Mark McCarthy at: editor@bamboo.org.au

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From the President

Each year The Bamboo Society is contacted by people asking various questions about bamboo uses, from building to what species to grow to make drinking straws. The most worrying one this year was from a company looking for a quick growing crop to grow on 10000 acres owned by AGL, with the aim to harvest using a specialised baler to produce round bales that would be left to dry and then burned at a power station to produce electricity. I was shocked at first wondering how this could be right? On further investigation, they are able to do this as it is classified as renewable energy. The plant, we know, has potential in the effort to deal with climate change. AGL want to burn it and make things worse.

As the public realises the usefulness of bamboo, mainly as screening plants, driven mostly by the modern world's desire to have things grow fast, governments are slow to respond to change, sometimes even taking backward steps. All *Bambusa* species are now on the NSW noxious weed list, with the only explanation as to why they are there is that they "exclude other vegetation".

Mark McCarthy

◀ *Lignania fimbriiligulatus*



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From the Editor's Desk

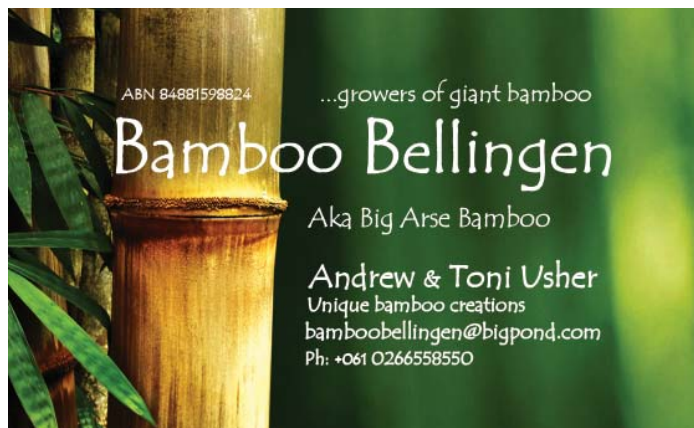
The last Bamboo and Rattan Conference held in Beijing demonstrated China's commitment to the growth of its bamboo industry. With natural stands of bamboo decreasing worldwide, China is increasing plantations and supplying a global market with everything from flooring to containers for cosmetics. Research into cross-breeding to develop superior hybrids has been undertaken for many years.

We start with a paper by Mittul Vanhanvarti on the benefits of bamboo in disaster relief, but also its vulnerabilities.

Mark McCarthy
Editor



Himalayacalamus falconeri Damarapa ►



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Reviving people's trust in bamboo technology: A case-study of Orlaha settlement reconstruction in Bihar after the 2008 Kosi floods

This selective synopsis of a 2015 paper by Mittul Vahanvati focuses on the bamboo aspects of her paper. Mittul's research has much broader social ramifications. The paper is available from the BSA web site under News Bamboo Research Papers. There are numerous images and much more detail in the paper that are well worth investigating.

BSA member and RMIT lecturer, Mittul Vahanvati produced a paper focusing on the technological and social process of reconstruction in a district of the Indian state of Bihar, after the 2008 Kosi floods. The flood event was one of most disastrous for Bihar. There is a substantial Wikipedia entry about it (look for 2008 Bihar flood).

An NGO group known as the Owner-Driven Reconstruction Collaborative (ODRC) undertook an assessment after the floods to see how best to use cost-effective, locally available materials and construction methods to reconstruct and move towards disaster-resilience in at-risk communities.

Bamboo was one of the recommended construction materials. There was ample good quality bamboo, along with local skills in traditional house construction. Most of the houses in the district were made from bamboo. Bamboo is central to the life of people in Mithilanchal. People there say, "from birth to death every step in their lives is supported by the bamboo". In this region, traditionally, most families grow their own bamboo groves and there are three main varieties of bamboo used for housing construction. "*Harot (Bambusa Balcoa)*, a thick walled, structural species is used for main structural frame of the house, the long straight *Chab (Bambusa Tulda)* is used for roof rafters and



The focus group with locals in Orlaha settlement.



Makhaur (Bambusa Nutans), along with other bamboos, is used for making the woven bamboo panels for wattle and daub wall. Bamboo houses were pre-fabricated either by a *Dabia mistry (bamboo artisan)* or by the householders themselves. Once all panels were ready, community members helped each other in assembling them. The roofs were typically made from thatch. The ODRC produced some guidelines to legitimise bamboo construction technology. Some of the issues that needed addressing were: Harvesting and treatment of bamboo; multi-hazard resistant design; and bamboo connection methods. The guidelines had to take into account three further considerations: no electricity, cost constraints, and the local high water table. For harvesting and treating the bamboo, the timing of harvesting is crucial. The guidelines recommend

harvesting in the dry season when the starch content is low in bamboo, as starch attracts borers and fungi. Also, the bamboo should be at least three years old. Despite this recommendation Mittul's research found that structural bamboo members in some houses were crushing because immature bamboo was used. With so much demand for bamboo in reconstruction after the flood, there was shortage of bamboo, prices had risen steeply, and householders had to buy whatever was available.

Treatment of bamboo is also a significant factor in the durability of bamboo. "Treated bamboo has a life expectancy of over 40-50 years as compared to an untreated one, which is only 4-5 years." The recommendation was to use a solution of boric acid, borax and copper sulphate, and treat the bamboo

The logo for Bamboo Australia features a stylized bamboo stalk and leaves. The text "BAMBOO AUSTRALIA" is prominently displayed. Below the logo, the address "1171 Eumundi-Kenilworth Road, Belli Park, QLD 4562" and phone number "PH 07 5447 0299" are listed. The email "sales@bambooaustralia.com.au" and website "www.bambooaustralia.com.au" are also provided. The text "Belli Bamboo Parkland" and "Open 7am to 4pm Monday to Saturday • Closed Sundays" are also included.

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The logo for Bamboo Bench Tops by Logan Leigh features a stylized bamboo stalk and leaves. The text "BAMBOO BENCH TOPS by LOGAN LEIGH established 1982" is prominently displayed. Below the logo, the names "SUZY SMITH office manager" and "MARK ATKINS factory manager" are listed. The address "67 Whitbread Street Taree NSW 2430" and phone number "Phone: +612 6551 5022 Fax: +612 6551 5023" are listed. The email "loganleigh@westnet.com.au" and website "www.loganleighbenchtops.com.au" are also provided.

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▲ *Bamboo artisan.*

in a temporary soaking pond that was dug in the agricultural fields and lined with plastic. The bamboo housing solutions needed to be multi-hazard resistant. For flood protection, three key features were introduced: An attic space to serve as a refuge in floods; strong and deep foundations with high plinth beams on which the house would sit; and, cement-stabilised mud plaster for bamboo-matt-woven walls, to allow plaster to give way to the pressure of water rather than compromising the structure. In the Madhubani region, bamboo architecture is almost as transient as their surrounding land and water form. Every year, mud plaster would wash away from wattle and daub walls leaving the bamboo woven wall-panels exposed, which being lightweight and easy to dismantle were removed, carried on boats by homeowners for relocation on higher grounds. People identify their way of living with the bamboo plant – being flexible from exterior to change with the changing circumstance but very strong from its roots or in personal values. The reasons for transient bamboo architecture are deeply rooted in the everchanging land-form.



◀ *Traditional bamboo housing typology.*

For earthquake resistance, the flexibility, lightness and high tensile strength of bamboo is ideal. Diagonal bracing members, between posts in all corners from plinth level to attic level give strength to the structure to withstand lateral thrust. Combined with lightweight walls and a lightweight roofing the system provides earthquake safety.

For safety against high-velocity winds, the connection of bamboo post with plinth beam and the walls to roof were modified to avoid uplifting. Mittul observed that these diagonal bracings were found in every house made out of bamboo.

The dwellings are constructed by local bamboo artisans, known as *dabia mistry*, who are skilled in bamboo construction. They are named for the knife, *dabia*, that is the main tool for working with bamboo. Lashing and bamboo pins were used as the two main bamboo connection methods to utilise the existing skill base (and lack of electricity). The local innovation of using of synthetic zipper fabric for tying instead of natural rope reduced maintenance, so it was incorporated in bamboo construction technology.

Some minor up-grades and new features did need to be added for multi-hazard safety. For example: tying columns to roof beams through a hole in bamboo to avoid uplift: using J-bolts in roofing members; and keeping bamboo columns higher on plinths to avoid moisture penetration.

Mitull's paper finishes with a discussion of the settlement six years after the flood. Her discussion is wider ranging than the brief synopsis here.

At the time of reconstruction, 39 of 41 houses built in the settlement, used bamboo technology. Householders chose bamboo over brick at that time for two main reasons: They believed the ODRC's claims that bamboo would last over 40 years if the technical guidelines were followed; and, with the financial assistance available to them, householders could build a two-room house with bamboo technology, but could build only a one-room house using brick technology.



◀ *Bamboo treatment in a soak pon. (photo: Hunnarshala)*



◀ *Attic space.*

Five years after reconstruction, satisfaction with bamboo technology was only about 50%. Despite the treatment of bamboo, innovations in construction technology and technical support, the majority of houses experienced borer infestation in the structural members. The cause for borer infestation was deemed to be the use of immature bamboo or incorrect treatment of the bamboo. Both steps in the construction process were the responsibility of the householders. For reasons that are unclear, some householders soaked the bamboo in plain water instead of the solution recommended and promoted by ODRC. Returning to paper title, *Reviving people's trust in bamboo technology*, the conclusion was drawn that no, local householders' faith in bamboo technology is not being revived, but is dropping in Orlaha settlement.

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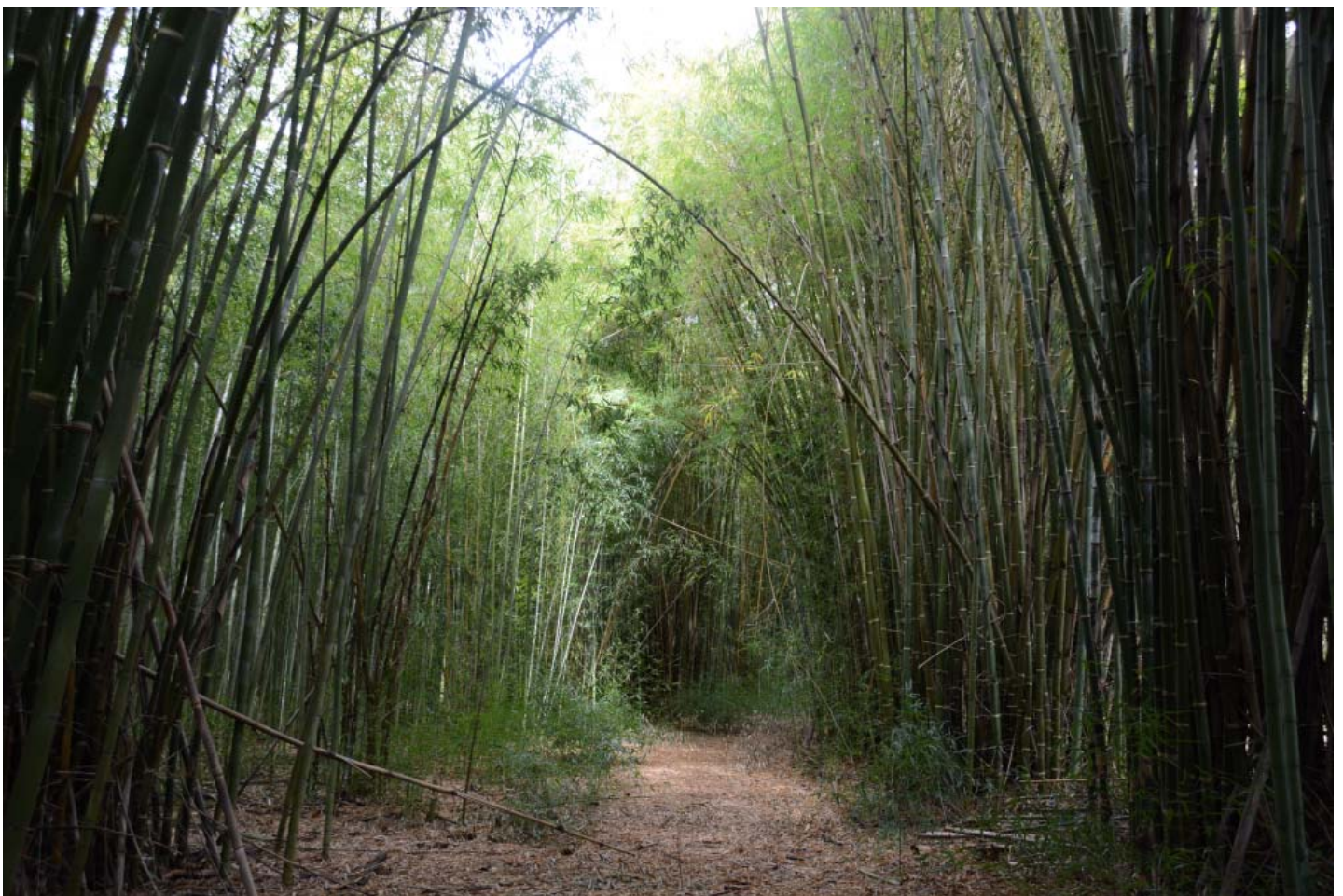
Bamboo Society AGM

The 2019 Annual General Meeting will be held at Durnford Dart's property Belli Bamboo Parkland at 1171 Kenilworth Road, Belli Park, Queensland on Sunday 10th of November.

Durnford started growing bamboo on his 100 acre property in 1989. He has recently developed a tourist trail through the many species of clumping and running bamboo. There will be a guided walk at 10am and the meeting will follow at 1pm, bring some lunch.

Available positions to be nominated at the Meeting are for President and Treasurer.

◀ *P. bambusoides*.



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Growing Plants with Bamboo

The fine, adventurous roots of bamboo are ideal for stabilising soil against erosion and controlling the growth of grasses, but in a garden situation they can restrict the growth of other plants. Some plants will tolerate this tough environment and create an interesting contrast to the tall culms. The contrast plants should be planted before or at the same time as the bamboo as it is difficult for the plants to establish in an advanced bamboo root system.

Below: Aspidistra at the base of B. textiles gracilis and opposite: Strelitzia Nicolai and Bromeliads amongst B. textiles gracilis.



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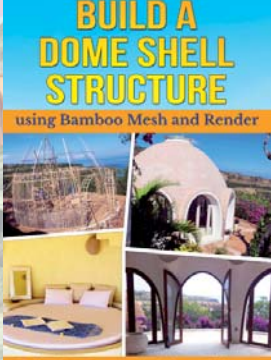
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Above: Bromeliads contrasting *B. textiles gracilis*. Below: Mauritius Hemp *Furcraea foetida* featured in front of *B. albostriata* Goldstripe. Opposite: *Furcraea selloa* var. *marginata* in front of *B. textiles* Gold.



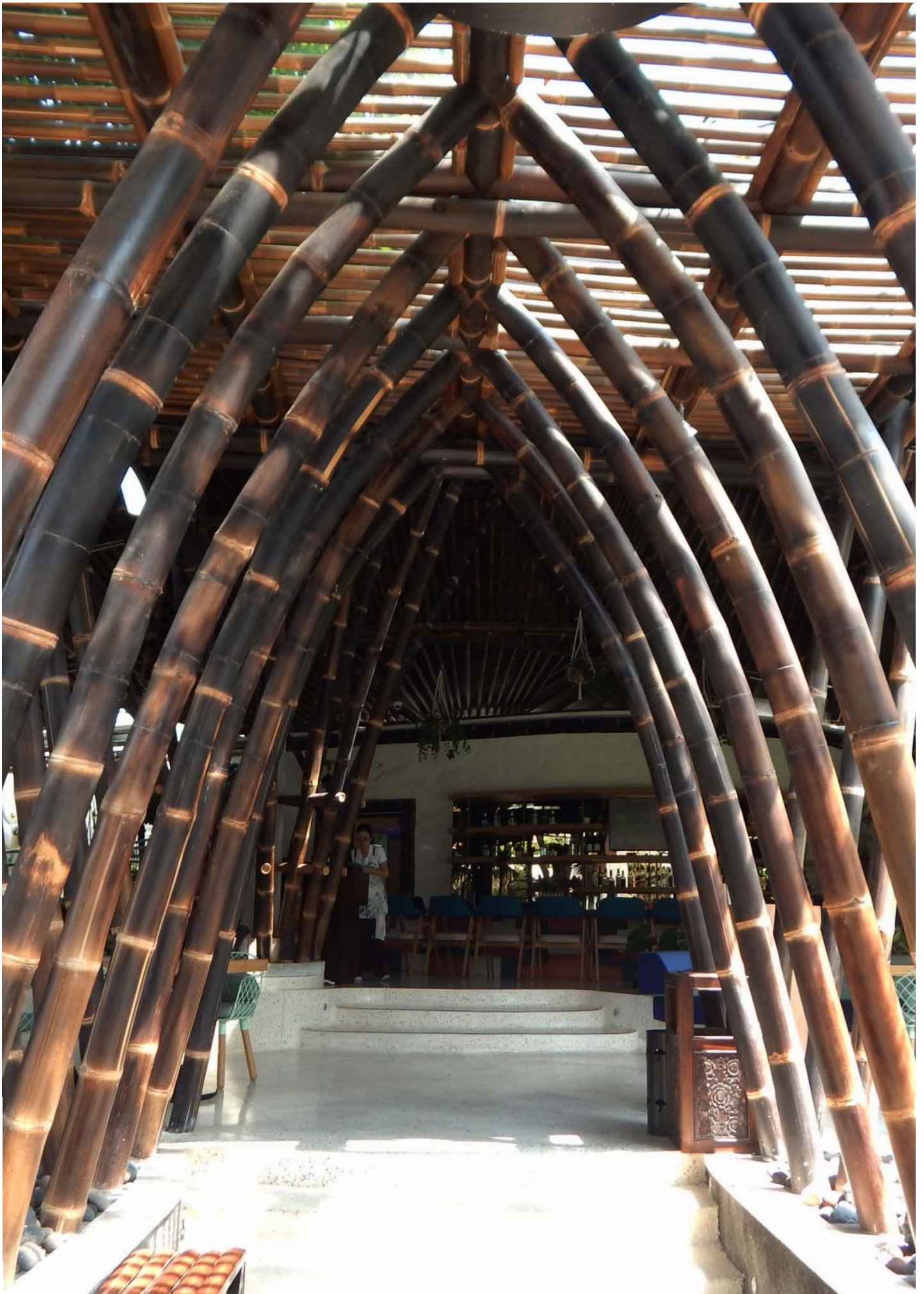


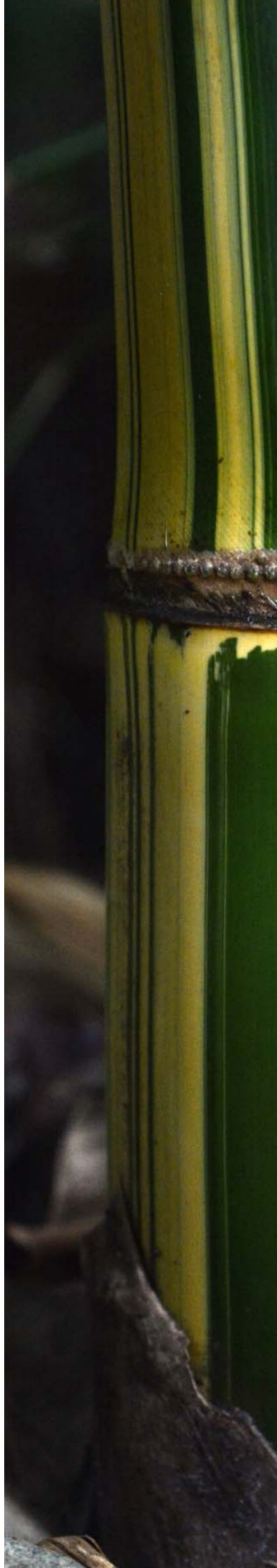
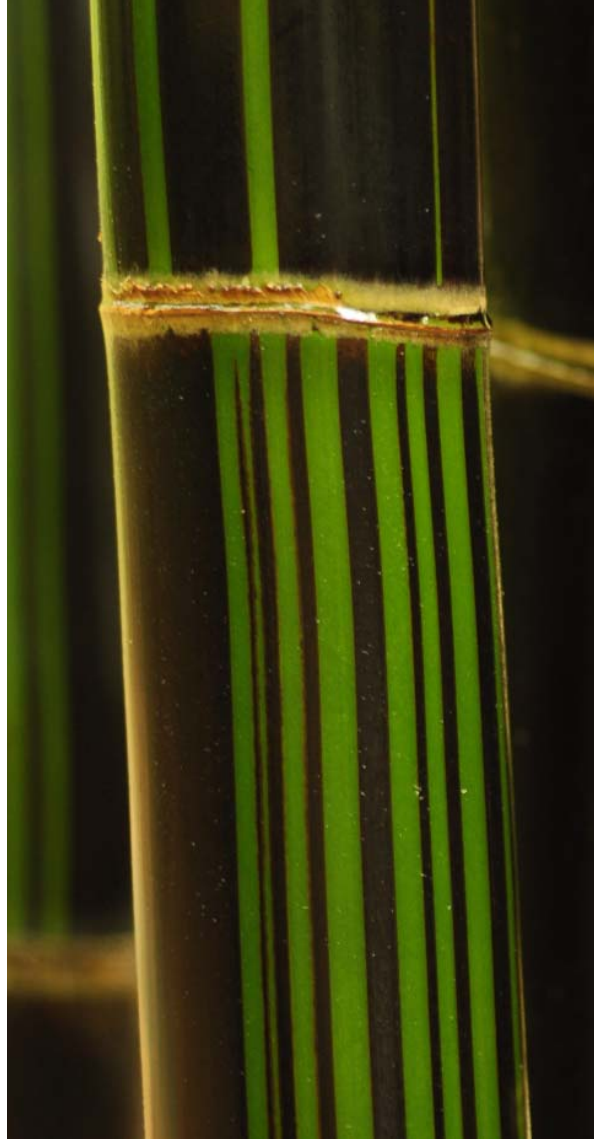


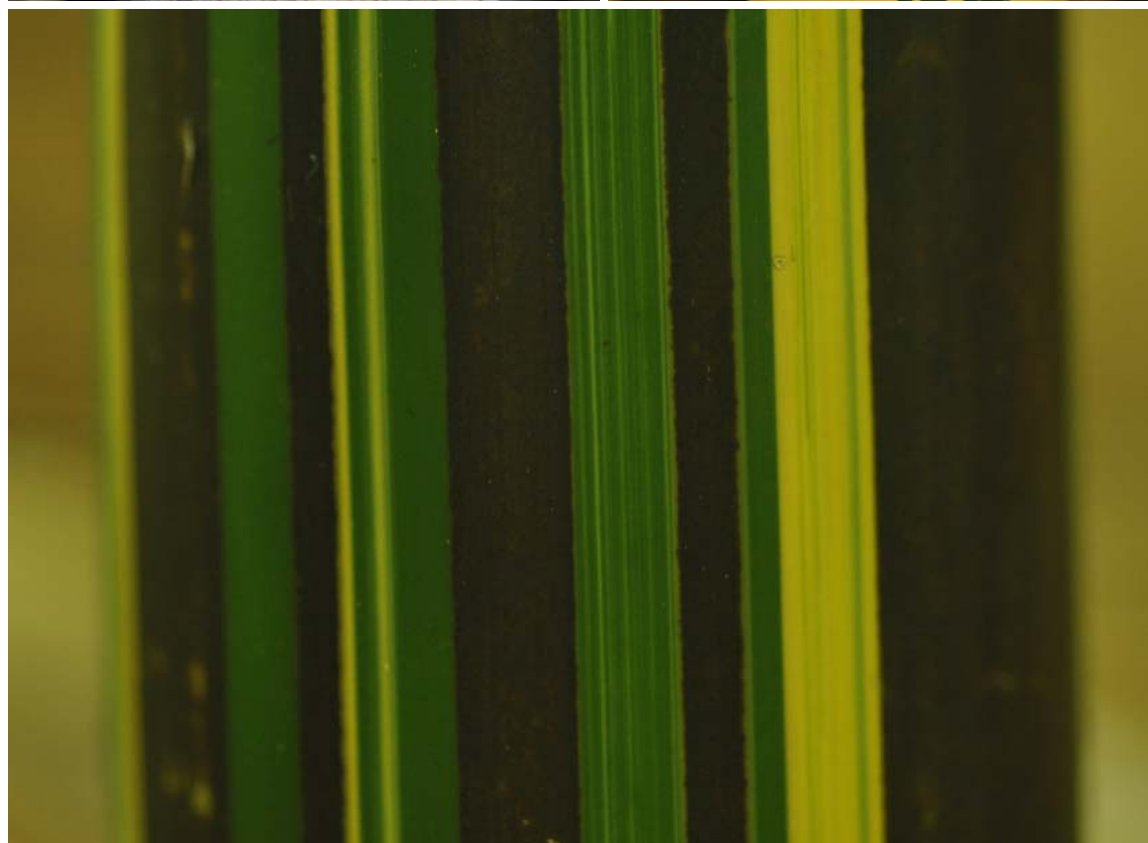
Black Bamboo Built

*Jim Mahoney found this interesting restaurant, constructed with *Dendrocalamus asper* Hitam, while overseas on holiday recently.*









Clockwise from above left: *Gigantochloa pseudoarundacea*, *Gigantochloa atrovioacea*, *Bambusa pervariabilis viridi striata*, *Gigantochloa* sp. Rachel Carson, *Bambusa vulgaris vittata*, *Bambusa lako*, *Dendrocalamus Maroochy*, *Bambusa dolichomerithalla*.



The Chill Zome

Last year Giant Grass was asked to build a structure in a local school that would provide shade and also be a quiet space for children. We came up with the idea of a “zome”, which is slightly different to a regular dome and has beautiful shape and proportions.

The design was done using computer modelling as there are eight different lengths of strips. The strips were manufactured in our workshop and holes were drilled at precise locations to ensure a correct fit.



The zome was assembled in the school with the help of parent and children over a weekend. Parts of the framing is woven with bamboo strips to provide enclosure and shade.

A short construction video is available on the following link: <https://youtu.be/2F6Hskxfpgw>



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China Bamboo and Rattan Congress

By Jaye Irving

I had the chance to present a talk during the Bamboo and Rattan Congress in Beijing (BARC), China. This event was organised jointly by INBAR (International Bamboo and Rattan Organisation) and China (several state administrations, provincial governments, institutes, research labs...)

The Conference

The BARC has been an international congress, including 43 countries, from diplomatic representation and government officials to bamboo and rattan experts and workers or private investors. The congress had a real policy-focused conferences, with topics and main

discussions concerning the promotion of bamboo and rattan as green tools and de facto as strategic resources; global aspect of sustainable developments such as the sustainable development goals, a collection of 17 global goals set by the United Nations in 2015. According to INBAR, bamboo and rattan are playing a key role at least to seven of those SDG: poverty alienation, clean energy, housing and cities, sustainable consumption, climate change, life on land (biodiversity conservation) and south-south cooperation.

China has sponsored a huge event, with more than 3000 participants, in the Olympic stadium in the heart of



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Beijing, with great show every night and amazing food. Money has been put on the table and we have been hosting with great ceremony! China really wants to be and own the leadership in sustainable development. With a bamboo industry which employs almost 10 million people, and is valued at US\$ 30 billion per year, Beijing is the perfect venue for this world-wide congress to come together and discuss green solutions for the future, especially with the Chinese Belt and Road Initiative. At the heart of it lies the re-creation of the original Silk Road, by land through Asia, Middle East and Europe, as well as a maritime road to Southeast and South Asia and the African coast, pushing up through the Suez Canal into the Mediterranean. It has been developed into a major Regional development plan, and for China it is a real an opportunity to promote South-South cooperation amongst the 60+ countries involved, and furthermore bamboo grows in many of the countries covered by the project. China is already providing training and capacity building for bamboo entrepreneurs. The concept of eco-civilization in a Chinese novelty, which was incorporated into the Communist Party of China Charter, indicating that it has been elevated to the centre of China's national development strategy. Eco-civilization is to balance the relationship between humanity and nature and is based on the socio-economic-environmental triangle of sustainable development, but also considers cultural and institutional aspects.

So the Chinese interest brings the world interest on bamboo and that is a very good news! Such as members of the Club of Rome for example! I had the chance to meet people from all over the world, including from places where Bamboo is not native at all, like Canada or even Russia or Norway! All with a keen interest in use and manufacturing of bamboo products.

My Presentation

I was approached by INBAR early this year to present a talk as part of panel discussing the “Bamboo as an Answer to Sustainable Living”. The Session was led by John Hardy of the Bali Green School and included several Architects working with bamboo in their practice. My presentation focused specifically on ephemeral and modular building and examined the implications within larger scale Bamboo projects. I had the opportunity to review a few of my ephemeral projects over the past 15 years and focused on a couple of case studies outlining the benefits of Modular and Prefabricated structures, especially in case of humanitarian aid and emergency shelters. In all it was well received, and I have made great contacts of people interested into this specific field of work.

Australian Opportunities

One of the major setbacks identified within the industry is that we will run out of raw material within 5 years at the present state of growth and demand. The business opportunities for Australia could be great if more bamboo was planted as a remedial crop in the tropical and subtropical regions of Australia. Imagine replacing existing cane lands not only for material resources but also for the carbon sequestering and biomass accumulation. A rise of material resources would also allow for the fabrication of bamboo-based products within the country rather than sending raw material overseas.

The whole world is taking very seriously the ecological challenges that mankind is facing, and the official answer of the Australian government is not enough. An official Australian representation in INBAR would be a good start as well as adopting bamboo construction standards.



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Bamboo in China: new prospects for an ancient resource

Wenyue Hsiung
Professor at Nanjing Forestry University,
Nanjing, China.

For centuries, bamboo has been put to a bewildering variety of uses by the people of China. But even more is expected from bamboo in the future as China's forest managers and researchers work with growers and users to improve yields and develop new processing technologies.

In Chinese culture bamboos symbolize gentleness, modesty and serenity. Indeed, bamboos have played a vital role in the development of Chinese culture and civilization and are still important today in Chinese rural economics and for industrial uses.

In fact, although the use of bamboo in China goes back almost 5 000 years, an increase in presentday demand and improved processing techniques point toward potentially rapid growth of the bamboo-based industry in China. Research will greatly contribute to the success of the venture.

China is rich in bamboo resources. Of the more than 1200 bamboo species and varieties within about 70 genera in the world, China has more than 400 species and varieties belonging to 34 genera. The total area of China's bamboo resources, exclusive of small undergrowth or alpine thickets, is about 3.4 million ha, nearly 3 percent of the country's total forest area and one-quarter of the world bamboo area.

Bamboos are closely associated with Chinese civilization. Their use can be traced back as far as the New Stone Age, as is indicated by the bamboo mats and baskets unearthed from the ruins of Hemodu and Shishan in Zhejiang Province, which were estimated to be some 4 800-5 300 years old. Bamboo articles were recorded in the oldest Chinese characters inscribed on bone and tortoiseshell unearthed from the ruins of the Yin Dynasty (1600-1100 BC) in Anyang, Henan. During the Zhou Dynasty (1100-300 BC) small culms were used as fishing-rods, larger culms were split into slips on which historical events were recorded, musical instruments were made of bamboo and bamboo shoots were cooked and eaten with fish and meat. In the Jin Dynasty (313-420), more than 200 agricultural implements and everyday items were made from bamboo. About 1100 years ago young culms were used for pulping and papermaking. Improved bamboo paper has been graded as the best for Chinese painting and handwriting. In ancient wars bamboo bows and arrows were effective weapons, and the first firearms and missiles were made from culms after the invention of gunpowder in China.

Distribution

Geographically, bamboos occur throughout China, from the southern tip of Hainan Island to Beijing and from Langxiaan in Tibet to east Taiwan, covering the tropical, subtropical and part of the temperate regions. They are distributed from sea-level up to 3 800 m high in the mountains of Tibet and Sichuan. However, most bamboos are thermophilous and are mainly confined to river basins and hilly land with fertile soil and a humid climate in the tropical and subtropical regions. Ecologically, bamboos with leptomorph rhizomes occur mostly in the Huang He (Yellow River) and Chang Jiang (Yangtze River) valleys and those with pachymorph rhizomes in south China. Between them lies a transitional zone of both rhizomal types.

Since 1950 China's bamboo area has increased rapidly (see Table). In particular, the area of *Phyllostachys pubescens*, the most important commercial species, has been enlarged by about 82 percent and now covers 2.42 million ha: 71.2 percent of China's total bamboo area.

Scientists and foresters are being encouraged to work on bamboo problems with financial support from the Government.

In Chinese culture bamboos symbolize gentleness, modesty and serenity.

Production and management

The total standing stock of bamboo in China is about 71.22 million tonnes and the annual yield about 7 million tonnes, approximately 2 tonnes per hectare, to which *Phyllostachys pubescens* contributes 56.5 and 5 million tonnes respectively. Other important bamboo species are *P. bambusoides*, *P. glauca*, *P. nidularia*, *P. viridis*, *P. propinqua*, *P. aurea*, *P. makinoi*, *P. nude*, *P. aureosulcata*, *P. nigra* var. *henonis*, *P. flexuosa*, *P. congesta*, *P. praecox*, *P. vivax*, *Arundinaria amabilis*, *Pleioblastus amarus*, *Bambusa textilis*, *B. perveriabilis*, *B. rigida*, *B. oldhami*, *Dendrocalamus latiflorus*, *Sinocalamus affinis*, and *Lingnania chungii*. These either occur naturally or are planted on a lesser scale in their appropriate regions and

Phyllostachys pubescens ►



managed either for culm yield, for shoot production or for dual purposes.

Many bamboos are cultivated in villages for rural consumption. Such bamboo groves vary from a few clumps of bamboo to plantations of a hectare or more. The management of bamboo stands has long been practiced in China and bamboo farmers have accumulated a wealth of silvicultural experience. It is estimated that an additional 2 million tonnes of culms are produced annually from village bamboo groves.

In recent decades the government has encouraged farmers to exercise intensive management of bamboo stands, including the control of felling, weeding, soil conditioning, fertilization and the elimination of pests. Annual yields of culms as high as 10-15 tonnes per hectare have been recorded in Shimen, Shuangyi and Moganshan (Zhejiang), Taoyuan (Hunan), Chishui (Guizhou) and Changning (Sichuan) for *Phyllostachys pubescens*, in Loning (Henan) for *P. glauca*, in Bo'ai (Henan) for *P. bambusoides*, in Huaiji (Guangdong) for *Arundinaria amabilis* and in Guangning (Guangdong) for *Bambusa textilis* and *Lingnania chungii*. Similarly, shoot production of *P. pubescens*, *P. praecox*, *P. vivax*, *Dendrocalamus latiflorus* and *Bambusa beecheyana* has reached 20-30 tonnes annually per hectare in Zhejiang, Fujian and Guangdong. About 10 percent of bamboo stands are now under intensive management.

Utilization

The Chinese people have used bamboos widely because of their easy propagation, vigorous regeneration, fast growth, high production, quick maturity, short rotation and graceful form. The particular qualities of bamboo culms - straightness, lightness, strength, hardness, high fibre content and easy workability - are ideal for different technological purposes.

For example, bamboo has traditionally been used in all parts of house construction, except for chimneys and fireplaces. Bamboo houses and constructions are still commonly seen in rural areas, particularly in the southern provinces. Beams, frames, floors, walls, partitions, ceilings, doors and windows can be made from culms in round or in split form. Long culms are laced together for scaffolding for high buildings and bamboo mats serve as protection during construction.



▲ *Dendrocalamus latiflorus*

Bamboo is also commonly used for a great number of general construction purposes. Bamboo bridges can be built either by tying together large culms for small streams or by suspending bamboo cables twisted from culm splits. Bamboo rafts are still an important means of transportation in areas with shallow rivers. Ladders, furniture, musical instruments, sports equipment, spears, bows, arrows, fishing-rods, tool-handles, fishing-net frames, boating poles, etc. can also be made of round culms according to their particular size and quality.



▲ *Bambusa beecheyana pubescens*

Many agricultural implements are made of bamboo, including irrigation wheels, water-pipes, hoe-handles, hand-rakes, aeration mats, sieves, screens, windows, fans, thrashing sticks, carrying rods, grain containers, granaries and supports for vines, beans, gourds, bananas and aquatic crops.

Many works of art and various everyday commodities are made from bamboo culms, splits and strips. They include flowerpots, furniture, lamp-stands, lampshades, sun blinds, painted curtains, fans, brooms, chopsticks,

fruit containers, sleeping and cushion mats, bookshelves, umbrella handles, laundry poles, baskets, ladies' bags, etc. In southern Yunan, villagers use the larger culms of *Dendrocalamus sinicus* to make buckets for water.

Apart from traditional uses, however, bamboo is also an important material in modern industry. Culm splits are used to reinforce concrete as a substitute for steel in some constructions. Bamboo pulping and papermaking have long been practiced and are still common in the Chinese countryside. Four tonnes of fresh culms are generally needed to produce one tonne of unbleached pulp. Modern paper mills do not use bamboo much as a raw material because of its impurity and cooking costs. However, because of the increasing demand for paper, several modern bamboo paper mills will need to be established within a few years.

During the Second World War, "plybamboo" was produced in China for aeroplane material. As a result of technological improvements various types of bamboo boards are now being manufactured. Bamboo mats are prepared by weaving culm strips. Bamboo veneers are peeled by machine from large culms about 3-4 m long that have been pretreated in boiling water. Bamboo sheets are also produced by breaking and widening the large culms after hot-water treatment. They are easily conditioned and are glued together into boards of determined size, number of layers and thickness in the same way as plywood. Plybamboo boards can be used for furniture, floors, walls, doors, ceilings, boxes, cement frames, windmill-blades and ornamental purposes. In addition, particle boards can be manufactured from bamboo chips. Trays, pans, containers and spindles

can be moulded by gluing fine culm strips with sawdust. Processed bamboo products and ornamental items are increasingly in demand for export and for domestic consumption.

Multiple uses of bamboo

Bamboo shoots are considered a nutritional vegetable. They come either from intensive plantations or from natural stands and are sold fresh, dry, pickled or canned mostly for domestic consumption.

The rhizomes of monopodial bamboos are used to make walking-sticks, pipes, whips and hand-crafts. Long



rhizome necks of *Pseudostachyum polymorphum* are characteristic for their high elasticity and durability in water and are traditionally used to make fishing-net frames. Culm stumps make good material for carving and can also be used to produce active charcoal. Bamboo roots are used for making cords and brushes once their hard cortex has been removed.

Bamboo farmers have accumulated a wealth of silvicultural experience.

Long bamboo branches of *Phyllostachys pubescens* and small bamboos are commonly used for binding brooms and whips and for hedges. Bamboo leaves make good forage for cattle. The larger ones can be used to thatch tent roofs, for hat-making and wrapping food. Young culms and leaves of *Sinarundinaria* bamboos serve as the main food source for the giant panda in the mountains of west China where pandas live in the wild. Culm sheaths of large bamboos of a considerable size, toughness and flexibility are used for wrapping goods, making hats, coarse sandal weaving, cord twisting, filling and pulping. The juice of *Phyllostachys* bamboos obtained from one end of a culm section by heating the other is an effective cure for fever. Tabasheer is a siliceous material secreted from the culm of some species and is commonly used as a cooling tonic, an aphrodisiac and for other healing purposes.

Together with plums, orchids and chrysanthemums bamboos are common in many gardens. Their colourful culms with their peculiar nodes and graceful foliage are always a beautiful feature of parks, scenic spots, historical sites and villages in south China. Species commonly used for ornamental purposes are *tortoise-shell bamboo* (*P. pubescens* var. *heterocycla*); *manlace bamboo* (*P. aurea*); *golden bamboo* (*P. viridis* f. *youngii*); *goldjade bamboo* (*P. aureosulcata* f. *spectabilis*); *purple bamboo* (*P. nigra*); *tear bamboo* (*P. bambusoides* f. *tanakee*); *Buddha's-belly bamboo* (*Bambusa ventricosa*); *abacus-bead bamboo* (*Qiongzhueta tumidinoda*); *square bamboo* (*Chimonobambusa quadrangularis*), etc. Small bamboos such as *Bambusa multiplex* var. *nana* can be used for living hedge.

Bamboos are valuable plants for wind-breaks and soil conservation because of their heavy evergreen foliage and extensive root system. They are often planted along river banks, lake shores and hilly slopes to prevent soil erosion. In rural areas farmers always plant small bamboo groves around their homesteads.

Research

In the past bamboos were considered a perpetual resource because of their vigorous vegetative propagation and regeneration. However, uncontrolled exploitation




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▲ *Dendrocalamus latiflorus* cross *Bambusa* sold in Australia as *latiflorus* Small Leaf. Below: *Bambusa chungii*.



results in a reduced yield and a deterioration in quality. Since it has been forecast that bamboo will become increasingly important for rural economic and industrial development attention has been paid in recent decades to bamboo production and utilization. Scientists and foresters are being encouraged to work on bamboo problems with financial support from the government.

Biology

Much confusion exists about the taxonomy of bamboo plants in China and the rest of the world Chinese botanists and foresters have made a great effort to investigate, collect, identify and classify bamboo plants in China and have clarified some of the taxonomic confusion. Many new bamboos have been discovered and described and several new genera established. A volume on bamboos in China is in preparation. Meanwhile, a number of bamboo gardens have been established in Hangzhou, Nanjing, Guangzhou, Nanning, Chengdu and Anji to serve as gene pools for further studies on genetics, breeding and taxonomy.

Investigations, observations and experiments have been carried out dealing with growth patterns, morphological characteristics, physiological mechanisms, anatomical features, ecological habits and the genetic make-up of important bamboos such as *Phyllostachys pubescens*, *P. glauca*, *P. vivax*, *Arundinaria amabilis*, *Sinocalamus affinis*, etc. Since the 1970s Nanjing Forestry University and other institutions have conducted research on nutrient content, anatomical characteristics, intercalary meristem, culm structure and the combustion value of major bamboos. A number of permanent plots have been established over bamboo areas for phonological observation and experiments of material-energy flow in bamboo ecosystems in relation to their ecological structure and silvicultural management.

Apart traditional uses, bamboo is also an important material in modern industry.

Processing techniques and machines have been studied and designed to meet the increasing demand for bamboo products.

The flowering behaviour of *Phyllostachys pubescens*, *Bambusa textilis*, *B. pervariabilis*, *P. sinospinosa*,

Dendrocalamus latiflorus and *D. minor* has been systematically observed and recorded to facilitate breeding bamboos in Guangdong Institute of Forestry. Several desirable hybrids have been created: *Bambusa pervariabilis* X *Dendrocalamus latiflorus* (*B. textilis*) 1; *B. textilis* X *D. latiflorus* 4; *B. pervariabilis* X *D. latiflorus* 25; and *D. minor* X *D. latiflorus* 5, all of which have better properties than their parents regarding culm straightness, growth vigour, culm strength and shoot taste. The chromosome number of their vegetative cells has also been observed and checked. In addition to 72 and 48 chromosomes commonly seen in many bamboo species, 64 also exist in *Bambusa textilis* and *B. pervariabilis*.

Silviculture

In the early 1950s Guangdong and Guangxi Institutes of Forestry conducted systematic research on the vegetative propagation of *Bambusa textilis*, *B. pervariabilis* and *Lignaria chungii*, important commercial bamboos in southern China. Culm nodes and large branches with dormant buds were selected for cuttings that produced a large number of young propagules for planting. Such work contributed greatly to the development of bamboo production in Guangdong and Guangxi.

Most research has been done on the culm yield of *Phyllostachys pubescens* by Nanjing Forestry University, the Chinese Academy of Forestry and other institutions. Stand density, protection, weeding, soil conditioning, fertilization and pest control are the major subjects of such programmes. The results obtained, together with traditional experiences, constitute an integrated system of silvicultural techniques in bamboo management. Accordingly, bamboo stands are classified into high-, medium- and low-yield groups on the basis of their productivity and site conditions. For different classes the appropriate silvicultural techniques are designated.

Traditionally, plantations of *Phyllostachys pubescens* are managed under an alternate on-and-off year system. This however has its weaknesses as far as annual production is concerned. Consequently, physiological and silvicultural approaches have been conducted to convert on-and-off year stands into even ones.



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Since the 1970s some successful research has been done on the introduction of bamboos to areas outside their natural ranges. As a result, some southern bamboos have been well acclimatized in the north. *Phyllostachys pubescens* grows safely in Wendeng and Laoshan, Shandong. *Arundinaria amabilis*, a native bamboo of Guangdong and Guangxi, becomes hardened in the Yangtze valley. *P. glauca*, *P. vivax* and *P. nigra* grow healthily outside their northern range. *Bambusa textilis*, *B. pervariabilis*, *B. multiplex* and *Sinocalamus affinis* have also artificially extended their northern distribution limit.

Insect and disease control

Many insects, such as *Ceracris kiangsu*, *Otidognathus davidis*, *A trachea vulgaris*, *Pegomyia kiangsuensis*, *Pantana sinica*, *Chionaspis bambusae*, *Arcona funeralis*, *Algedonia coclasalis*, caused serious damage to living bamboos in the 1960s. However, after a series of studies on their life history, occurrence and development, effective measures have succeeded in bringing the problem under control.

Diseases such as *Stereostromum corticioides*, *Balansia take*, *Shirarua bambusicala* and *Ustilago shiraiana* often occur in bamboo stands, but seldom cause any serious damage. The most destructive is *Ceraptosphaeria phyllostachydis* or culm dieback disease, first discovered in stands of *P. pubescens* along the coast area of Zhejiang in the early 1960s. This disease was widespread in northwest Zhejiang and along its borders and caused serious disaster in Chinese bamboo production. Studies by the Subtropical Forestry Institute on the disease's pathogenic origin, development and prevention eventually brought it under control.

Studies on the treatment of bamboo products against mould and borers are under way in some institutes. Nanjing Forestry University has achieved remarkable results in preserving *P. pubescens* products with liquefied acetyl under atmospheric pressure.

Utilization

Since the 1940s studies on the physical, mechanical and chemical properties of more than 70 bamboo species have been conducted. The results obtained show that bamboo moisture content in dry air is 15-18 percent; fibre saturation point 30-35 percent; volume-weight 0.60:0.77; radial shrinkage 4-5 percent; tangential shrinkage 3-4 percent; longitudinal shrinkage 0.3-0.5 percent; and



D. minor ▲

combustion value 4 550 4680 cal/g. Their tensile strength is twice that of timber wood and their compression is about 10 percent higher. Their fibre content ranges from 40 to 60 percent with 1500-2000 microns in length and 12-17 microns in width. Accordingly, bamboos can be classified for appropriate uses in various categories, such as mechanical, layer splitting, pulping and paper-making and shoot producing.

Processing techniques and machines have been studied and designed to meet the increasing demand for bamboo products, particularly bamboo plywood, particle boards and hardboards. Improvement is still being made. Secondary processing techniques such as bending, moulding, costing, polishing and dyeing, which are important for furniture, artistic articles and other fine products, are also included in research programmes.

Increasing pulp yield and reducing treatment costs are key problems that need to be solved in making paper from bamboo. A sustained supply of culms as raw

material presents another problem for modern paper mills. Current research programmes are studying these factors.

A number of universities, institutes and business units have undertaken important research projects related to bamboo production and Utilization. The Bamboo Research Institute, the first of its kind in China, was established in conjunction with the Bamboo Laboratory of Nanjing Forestry University. A national organization of bamboo workers known as the Chinese Bamboo Association (CBA) was established in 1984. Its aim is to promote scientific activities and the cooperation of bamboo workers both in China and abroad. In addition, three scientific periodicals are published. Bamboo Research and Bamboo Information are edited by the Chinese Bamboo Association and the Bamboo Research Institute, and the Journal of Bamboo Research by Zhejiang Institute of Forestry.

Conclusion

China is a country with great potential for bamboo production and utilization. Although some achievements have been made and traditional products have won a good reputation, greater efforts are still needed to increase bamboo plantations, promote the unit yield of bamboo stands and fully utilize bamboo resources. Research on different aspects of the bamboo industry is still in the initial stages. Further studies are urgently needed on bamboo taxonomy, genetics, ecology, silvicultural management, protection against pests, processing techniques and multi-use. More research work and international scientific cooperation should be encouraged for the development of bamboo production and utilization both in China and the rest of the world.

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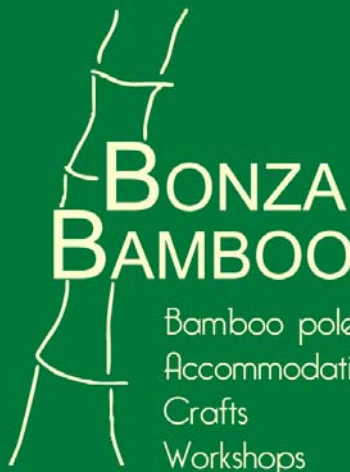
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